XI. "On the Thermal Effects of Fluids in Motion."—No. II. By J. P. Joule, Esq., F.R.S. and Professor W. Thomson, F.R.S. Received June 15, 1854.

The first experiments described in this paper show that the anomalies exhibited in the last table of experiments, in the paper preceding it*, are due to fluctuations of temperature in the issuing steam consequent on a change of the pressure with which the entering air is forced into the plug. It appears from these experiments, that when a considerable alteration is suddenly made in the pressure of the entering stream, the issuing stream experiences remarkable successions of augmentations and diminutions of temperature, which are sometimes perceptible for half an hour after the pressure of the entering stream has ceased to vary.

Several series of experiments are next described in which air is forced (by means of the large pump and other apparatus described in the first paper) through a plug of cotton wool, or unspun silk pressed together, at pressures varying in their excess above the atmospheric pressure, from five or six up to fifty or sixty pounds on the square inch. By these it appears that the cooling effect which the air, as found in the authors' previous experiments, always experiences in passing through the porous plug, varies proportionally to the excess of the pressure of the air on entering the plug above that with which it is allowed to escape. Seven series of experiments, in each of which the air entered the plug at a temperature of about 16° Cent., gave a mean cooling effect of about ·0175° Cent., per pound on the square inch, or ·27° Cent. per atmosphere, of difference of pressure. Experiments made at lower and at higher temperatures showed that the cooling effect is very sensibly less for high than for low temperatures, but have not yet led to sufficiently exact results at other temperatures than that stated (16° Cent.) to indicate the law according to which it varies with the temperature.

Experiments on carbonic acid at different temperatures are also described, which show that at about 16° Cent., this gas experiences $4\frac{1}{2}$ times as great a cooling effect as air. They agree well at all the

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different temperatures with a theoretical result derived according to the general dynamical theory from an empirical formula for the pressure of carbonic acid in terms of its temperature and density, which was kindly communicated by Mr. Rankine to the authors, having been investigated by him upon no other experimental data than those of Regnault on the expansion of the gas by heat and its compressibility.

Experiments were also made on hydrogen gas, which, although not such as to lead to accurate determinations, appeared to indicate very decidedly a cooling effect amounting to a small fraction, perhaps about $\frac{1}{16}$, of that which air would experience in the same circumstances.

The following theoretical deductions from these experiments are made :—

I. The relations between the heat generated and the work spent in compressing carbonic acid, air and hydrogen, are investigated from the experimental results. In each case the relation is nearly that of equivalence, but the heat developed exceeds the equivalent of the work spent, by a very small amount for hydrogen, considerably more for air, and still more for carbonic acid. For slight compressions with the gases kept about the temperature $16°$, this excess amounts to about $\frac{1}{77}$ of the whole heat emitted in the case of carbonic acid, and $\frac{1}{420}$ in the case of air.

II. It is shown by the general dynamical theory, that the air experiments, taken in connexion with Regnault's experimental results on the latent heat and pressure of saturated steam, make it certain that the density of saturated steam increases very much more with the pressure than according to Boyle's and Gay-Lussac's gaseous laws, and numbers are given expressing the theoretical densities of saturated steam at different temperatures, which it is desired should be verified by direct experiments.

III. Carnot's function in the "Theory of the Motive Power of Heat" is shown to be very nearly equal to the mechanical equivalent of the thermal unit divided by the temperature from the zero of the air-thermometer (that is, temperature Centigrade with a number equal to the reciprocal of the coefficient of expansion added), and corrections, depending on the amount of the observed cooling effects in the new air experiments, and the deviations from the gaseous laws of

expansion and compression determined by Regnault, are applied to give a more precise evaluation.

IV. An absolute scale of temperature, that is, a scale not founded on reference to any particular thermometric substance or to any special qualities of any class of bodies, is founded on the following definition :—

If a physical system be subjected to cycles of perfectly reversible operations and be not allowed to take in or to emit heat except in localities, at two fixed temperatures, these temperatures are proportional to the whole quantities of heat taken in or emitted at them respectively during a complete cycle of the operations.

The principles upon which the unit or degree of temperature is to be chosen, so as to make the difference of temperatures on the absolute scale, agree with that on any other scale for a particular range of temperatures. If the difference of temperatures between the freezing and the boiling-points of water be made 100° on the new scale, the absolute temperature of the freezing-point is shown to be about 273·7 ; and it is demonstrated that the temperatures from the freezing-point on the new scale will agree very closely with Centigrade temperature by the standard air-thermometer; quite within the limits of the most accurate practical thermometry when the temperature is between 0° and 100° Cent., and very nearly if not quite within these limits for temperatures up to 300° Cent.

V. An empirical formula for the pressure of air in terms of its density, and its temperature on the absolute scale, is investigated, by using forms such as those first proposed and used by Mr. Rankine, and determining the constants so as to fulfil the conditions (1) of giving the observed cooling effects, (2) of agreeing with Regnault's observations on expansion by heat, and (3) of agreeing with Regnault's experimental results on compressibility at a particular temperature.

A table of comparison of temperature by the air-thermometer under varied conditions of temperature and pressure with the absolute scale, is deduced from this formula.

Expressions for the specific heats of any fluid in terms of the absolute temperature, the density, and the pressure, derived from the general dynamical theory, are worked out for the case of air according to the empirical formula ; and tables of numerical results derived

exclusively from these expressions and the ratio of the specific heats as determined by the theory of sound, are given. These tables show the mechanical values of the specific heats of air at different constant pressures, and at different constant densities. Taking 1390 as the mechanical equivalent of the thermal unit as determined by Mr. Joule's experiment on the friction of fluids, the authors find, as the mean specific heat of air under constant pressure,

·2390, from 0° to 100° Cent.

·2384, from 0° to 300° Cent.

XII. " Note on Nitro-glycerine." By A. W. WILLIAMSON, Ph.D., F.C.S., Professor of Practical Chemistry in University College. Communicated by Dr. SHARPEY, Sec. R.S. Received June 15, 1854.
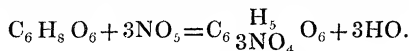
This compound is formed by acting upon glycerine with a mixture, in equal volumes, of concentrated nitric and sulphuric acids, the glycerine being added by a few drops at a time.

It is heavier than water, in which it is slightly soluble, and is soluble in alcohol and in ether.

From its proneness to decomposition in drying, even by the air-pump, a complete analysis could not be made, but a qualitative examination of the relative amounts of carbon and nitrogen gave the following results :—

	1.	2.	3.	4.
Volumes of mixed gases	101	91·5	99	97
Volumes of nitrogen not absorbed by potash	32	30·5	34	33
Carbonic acid absorbed by potash	69	61	65	64

	1.	2.	3.	4.	5.
Mixed gases	178	194	173	194	192
Nitrogen	61	66	58	65	65
CO_2	117	128	115	129	127

From these results the following formula was deduced :—

$$C_6 H_8 O_6 + 3NO_5 = C_6 \frac{H_5}{3NO_4} O_6 + 3HO.$$

It would therefore appear that 3H are replaced by $3NO_4$.

On boiling this compound with concentrated solution of potash, it is decomposed into glycerine and nitrate of potash.